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From Phantom to Phantom-Free: "AnatomIQ" an Automated CT Quality Assessment without Physical Calibration

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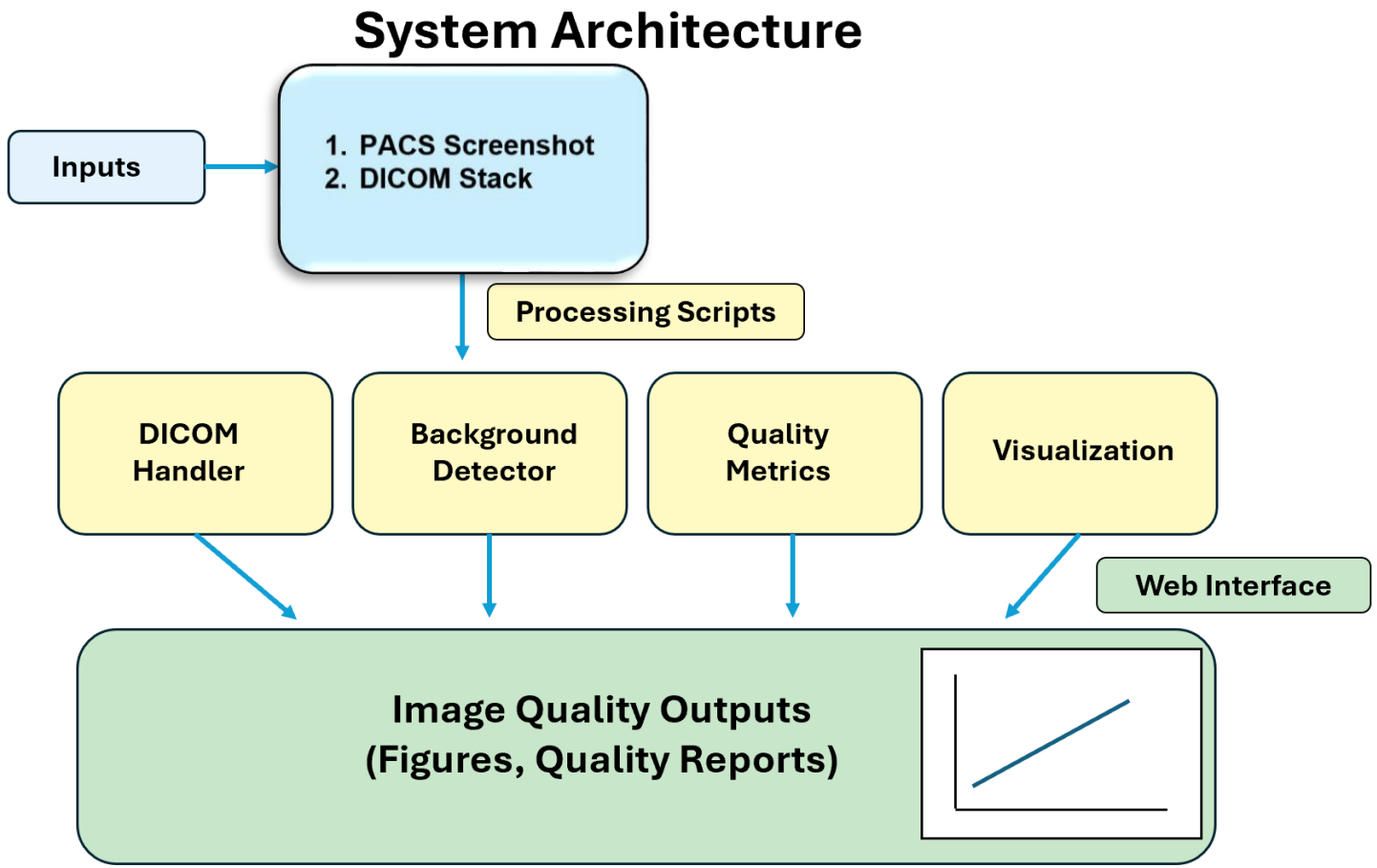
Disclosures

- R. Carballeira, H. Cash, M. Robins: Provisional patent application pending for AnatomIQ automated CT image quality assessment methodology.
- No financial conflicts of interest to disclose.

Motivation

- Why Current CT Quality Assessment Falls Short
  - Manual background ROI selection → >15% inter-operator variability in CNR
  - NPS and TTF require dedicated phantom acquisitions → extra radiation, cost, workflow disruption
  - Manual PACS-to-DICOM coordinate transcription → 10–20+ min/case, impractical for routine monitoring

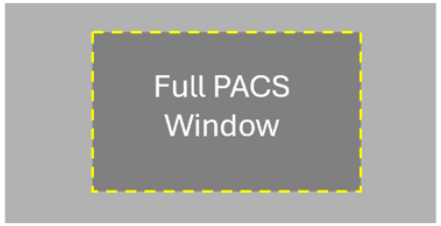
The Pipeline



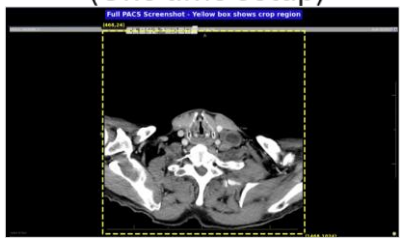
1. PACS Screenshot
2. DICOM Stack

PACS Integration Workflow

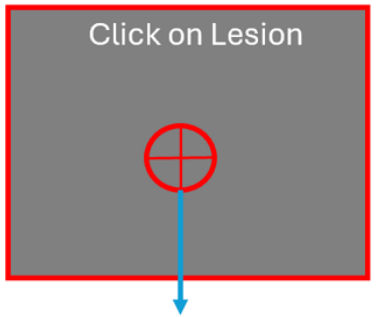
Step 1
Capture PACS Screenshot



Step 2
Define Crop Region
(One time setup)

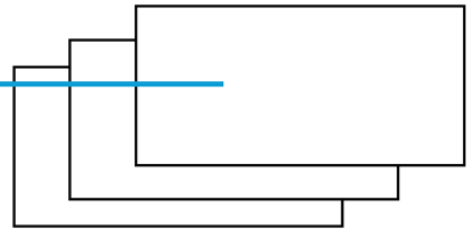


Step 3



Auto-extract XY Coordinates

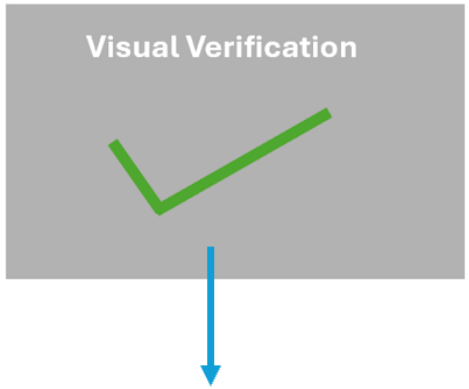
Step 4
Load DICOM Stack



Step 5
Transfer Coordinates

Auto-transformed coordinates in DICOM Space

Step 6



Step 7: Automated CNR Analysis

- **Background Detected**
- **CNR**
- **FOM**
- **Dose Recommendations**

Total time: ~2-3 minutes per case

Set crop region once for your PACS system, then use for all patients!

Upload Screenshot

PACS Screenshot (PNG, JPG)

Row 131 Slice 69.png 434.7 KB

Load Screenshot

Status

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SCREENSHOT LOADED
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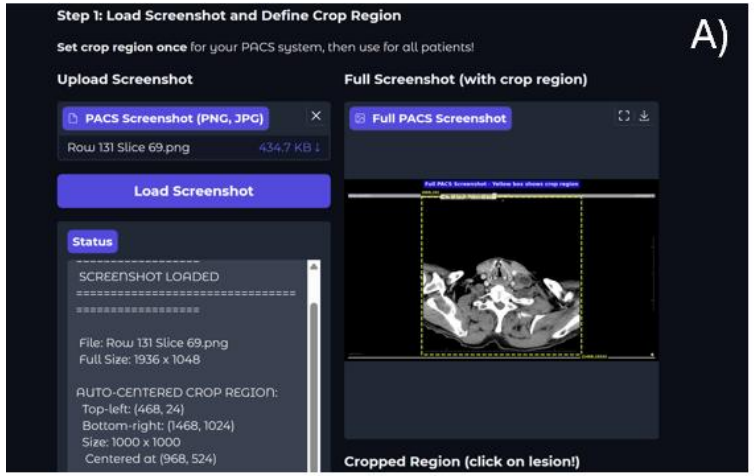
File: Row 131 Slice 69.png
Full Size: 1936 x 1048

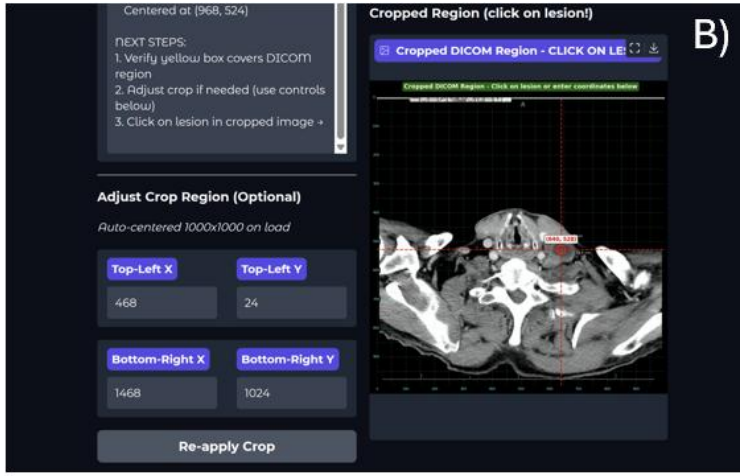
AUTO-CENTERED CROP REGION:
  Top-left: (468, 24)
  Bottom-right: (1468, 1024)
  Size: 1000 x 1000
```

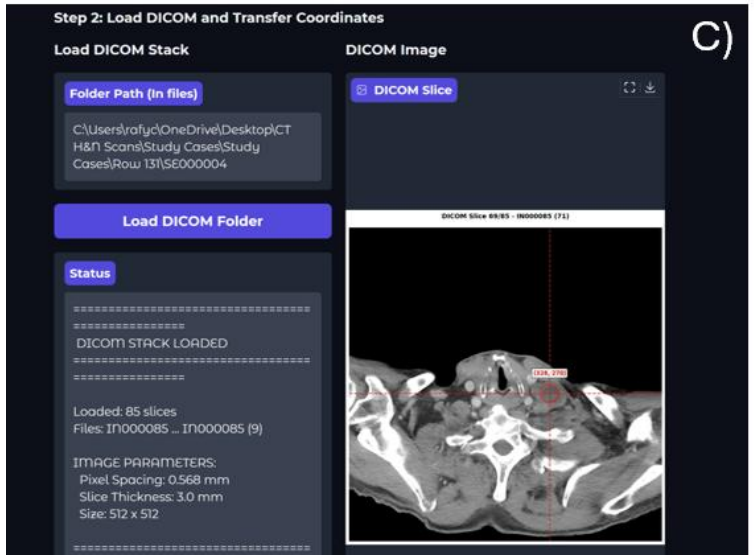
Full Screenshot (with crop region)

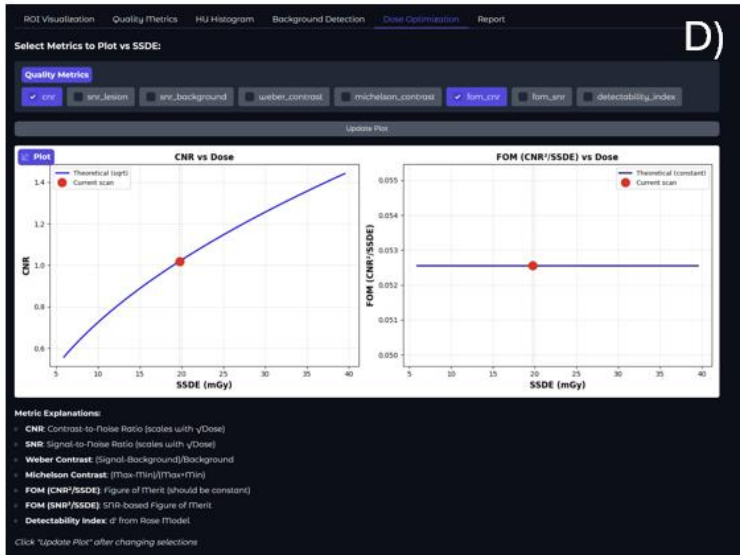
Full PACS Screenshot

User Interface

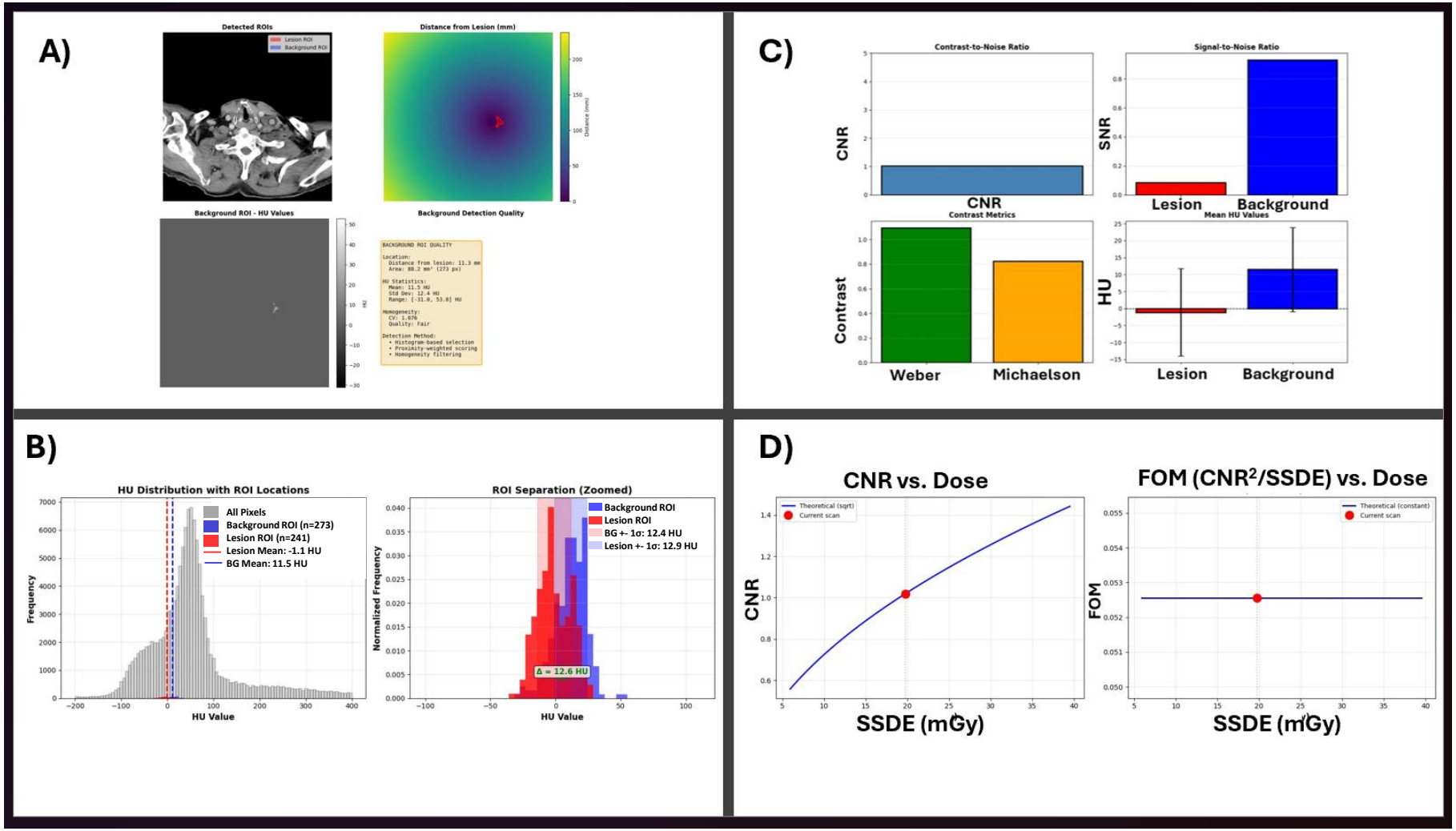






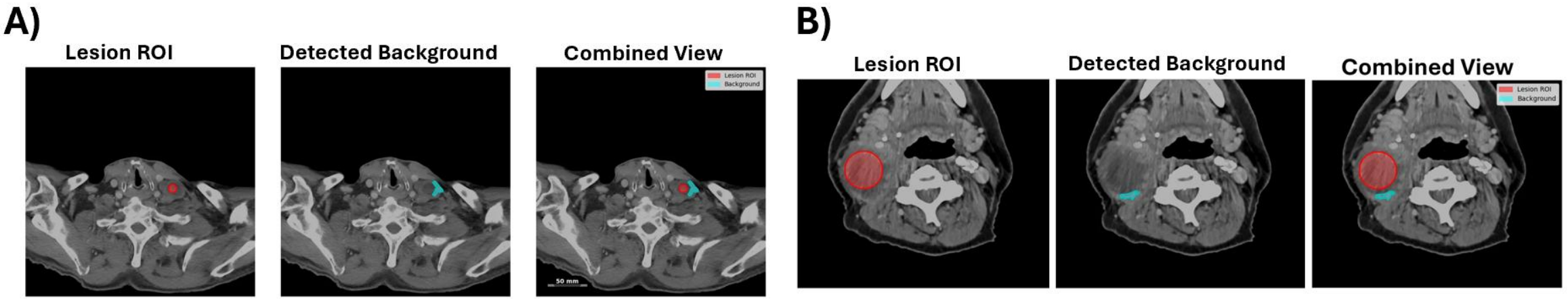


Hounsfield Unit Histogram Analysis



Automated Background Detection

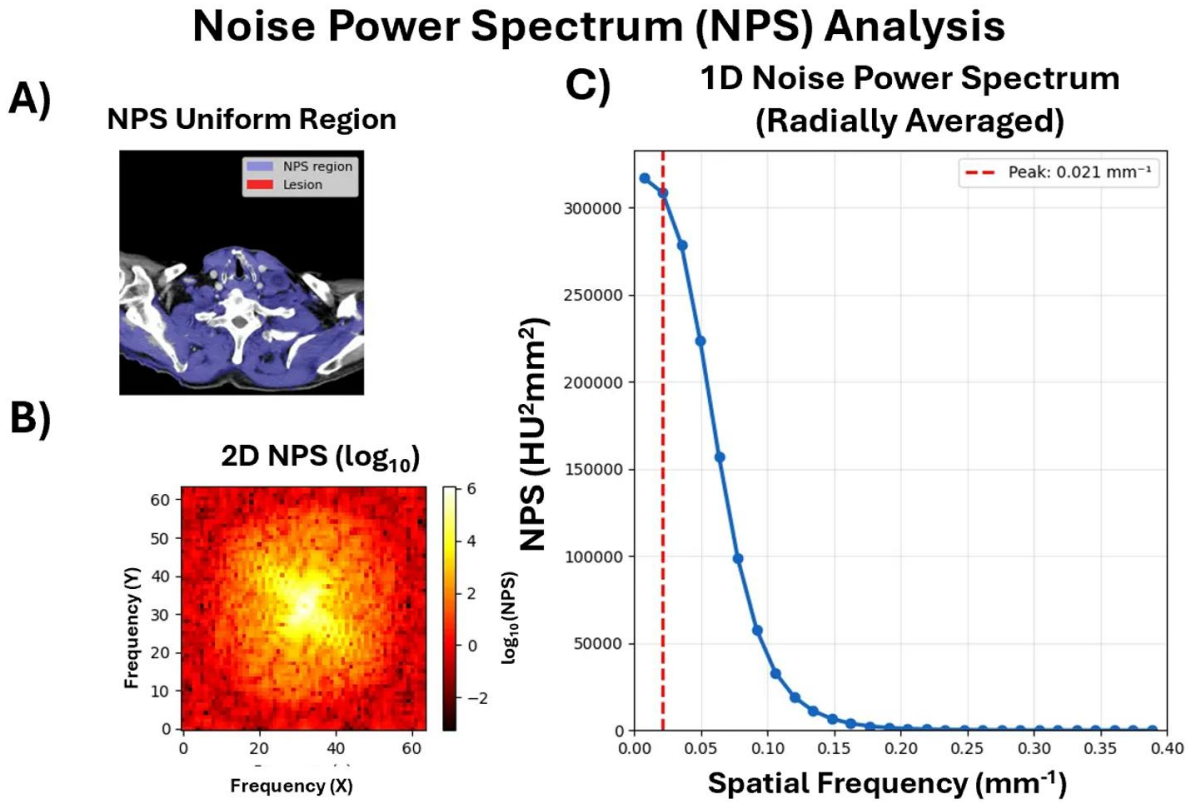
HU-adaptive thresholding: tissue-matched background for fat, soft tissue, and dense tissue



Quality flags: GOOD / WARNING / FAILED

Phantom-Free Noise Power Spectrum

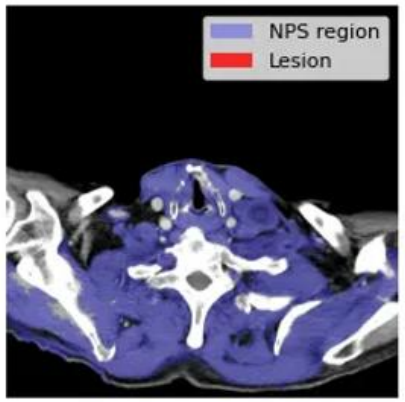
- NPS reveals noise texture in the spatial frequency domain — SD alone cannot distinguish fine vs. coarse noise
- Algorithm: auto-identify uniform tissue from CNR background mask → 64×64 ROIs → 2D FFT with Welch windowing → radially-averaged 1D NPS in HU²·mm²
- Output: peak spatial frequency → FINE / MODERATE / COARSE texture classification
- Validation: 218 cm² uniform region, peak freq 0.021 mm⁻¹ → coarse texture (consistent with smooth kernel)



Noise Power Spectrum (NPS) Analysis

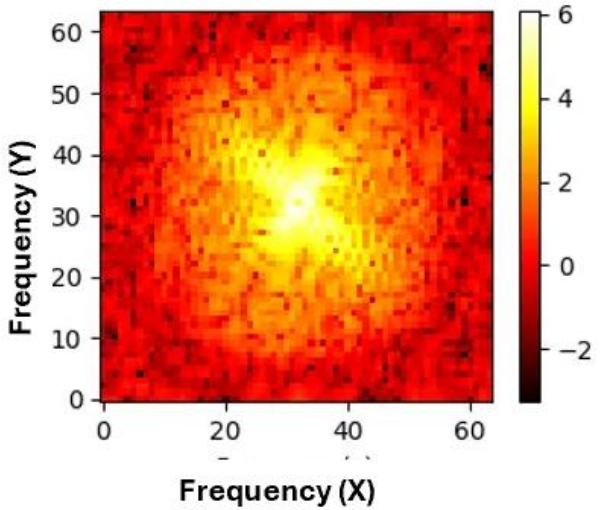
A)

NPS Uniform Region



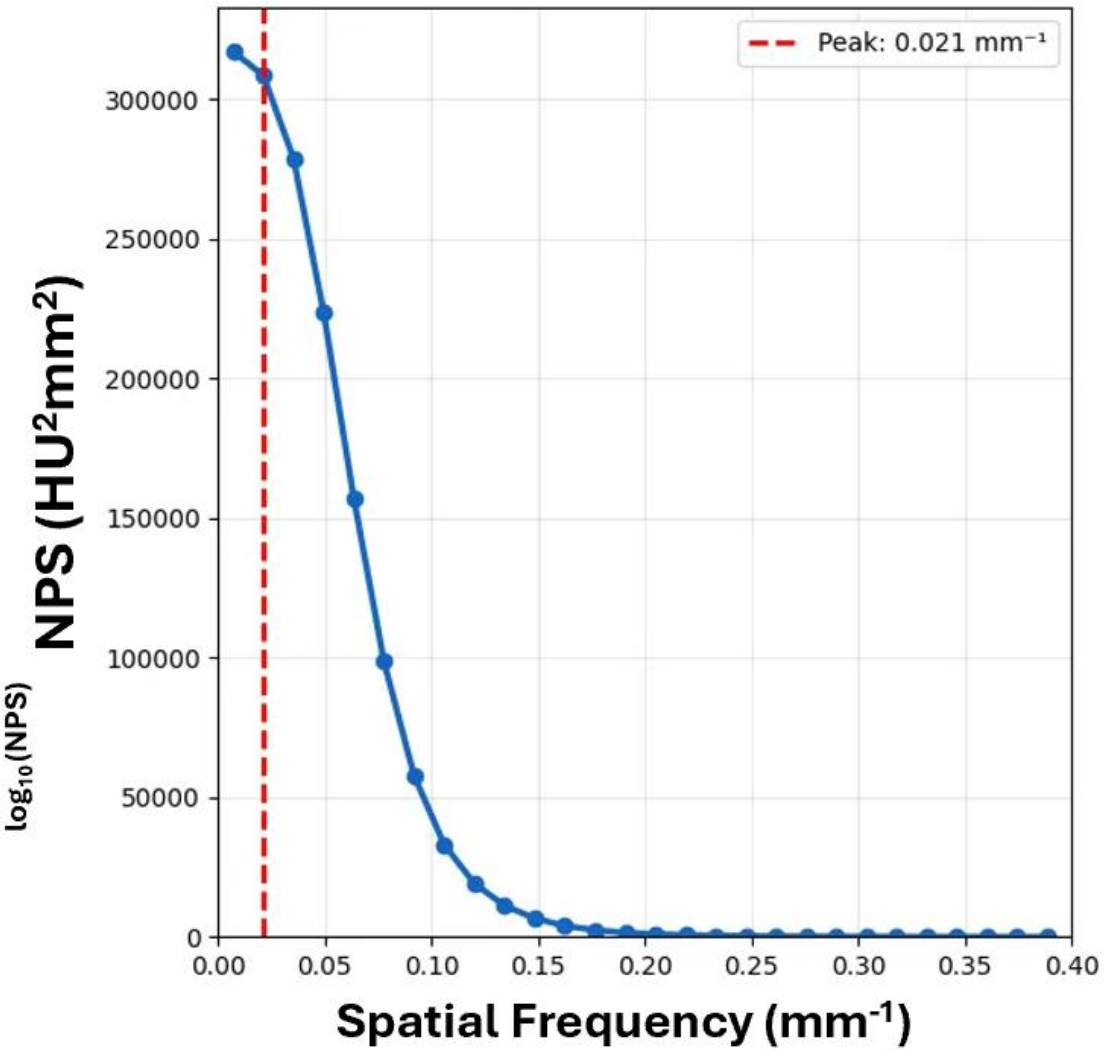
B)

2D NPS (log_{10})



C)

1D Noise Power Spectrum (Radially Averaged)



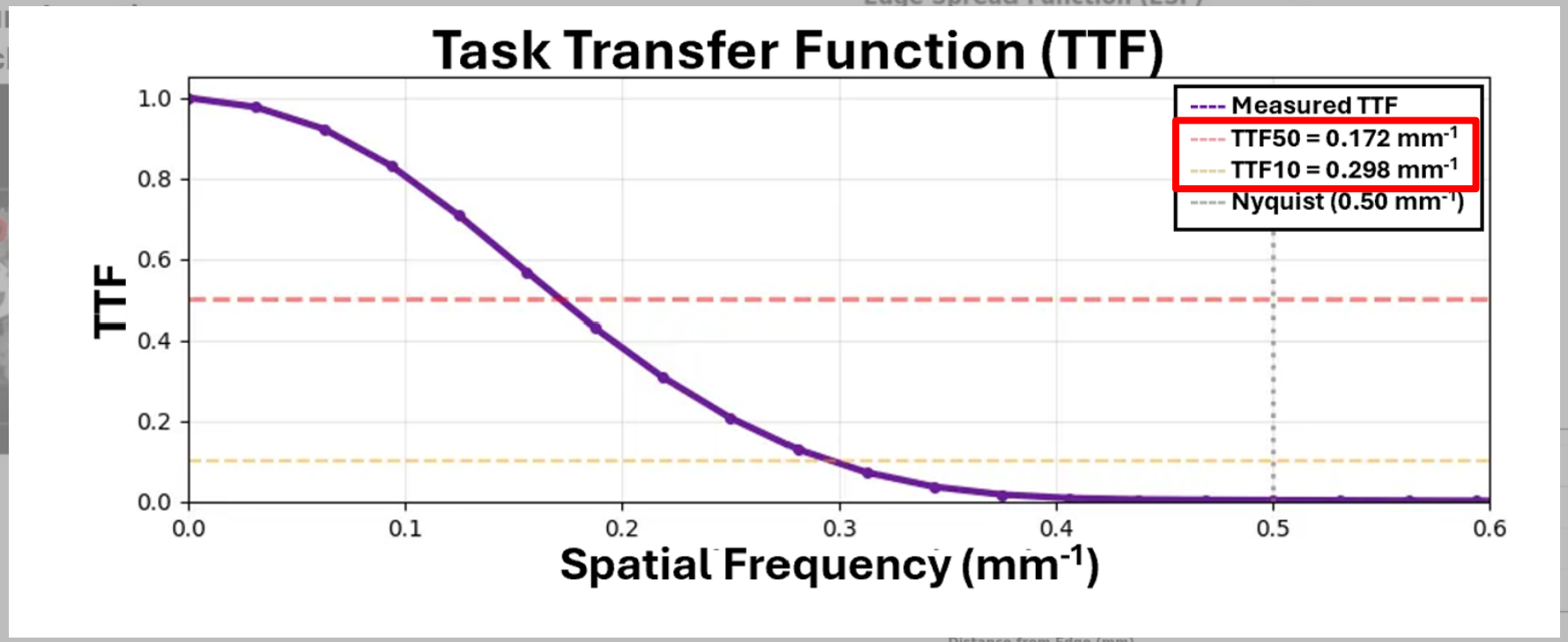
Phantom-Free Task Transfer Function

- TTF quantifies spatial resolution: system response vs. spatial frequency

Algorithm:

1. Hough circle detection (>200 HU contrast) → 180 radial profiles → ESF → LSF → Fourier transform → TTF
2. Uses vessels, trachea, airways as built-in edge phantoms
3. Captures real imaging conditions: patient motion, physiology, positioning — absent in phantom measurements
4. Validation: vessel quality score 0.89, TTF_{50} = 0.17 mm^{-1}, TTF_{10} = 0.30 mm^{-1} → smooth soft tissue kernel confirmed

Phantom-Free Task Transfer Function



Conclusion

- AnatomIQ automates the full CT IQ pipeline — PACS screenshot to comprehensive analysis in 2–3 minutes
- Eliminates operator-dependent variability in CNR background selection (>15% reduction)
- First open-source toolkit to perform both NPS and TTF directly from in vivo patient anatomy — no phantom, no additional radiation
- Anatomical TTF captures real imaging conditions absent from phantom measurements

Acknowledgements

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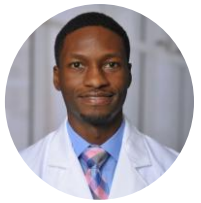
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